

Dissolved Oxygen Management and Related Costs in Pond Aquaculture



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YSI Aquaculture Monitoring & Control

Application Note A564-02

Dissolved oxygen control is critical in aquaculture. Dissolved oxygen (DO), the volume of oxygen contained in water, is often a critical parameter in the health and well-being of your livestock. In general, most fish species will grow and thrive within a DO range of 5-12 mg/L (ppm). However, if levels drop below 4 mg/L they may stop feeding, become stressed and possibly lead to catastrophic fatalities. This series of events can start a chain reaction in a pond aquaculture system that could prove detrimental.



Figure 1: An aquaculture pond facility receiving oxygenation through a paddle wheel. Accurately determining when to aerate can provide substantial cost savings.

Oxygen depletion usually occurs in the summer months because warmer water holds less oxygen than cooler water. For example, water with a temperature of 32°C can hold up to 7.3 mg/L of oxygen, while 7°C water can hold 12.1 mg/L. As water temperatures rise, oxygen levels decrease. Higher temperatures also increase the metabolic rate of fish resulting in the need for more oxygen.

In summer months, ponds can undergo stratification because of differences in water densities with differing temperatures. Cooler water sinks, warmer water rises, and the water at the top of the pond is heated more rapidly through radiation by the sun. Although the pond's cooler bottom temperature holds more dissolved oxygen when the summer starts, as the summer progresses, microbial decomposition of organic materials depletes oxygen at the pond's bottom.

In addition, an average pond experiences a DO diurnal cycle, which is a fluctuation in DO levels from day to night. Fluctuations can range from 2 to 3 mg/L during a 24 hour period. DO increases during the daylight hours when photosynthesis is occurring and decreases at night when respiration continues but photosynthesis does not. This natural diurnal cycle in aquatic systems fluctuates greatly and can be exacerbated in aquaculture systems with high stocking densities. See **Graph 1** for an average pond's DO diurnal cycle.

In order to accurately understand these differences and changes, most aquaculture facilities use oxygen sensors to monitor dissolved oxygen and prevent oxygen depletion through monitoring and control. If levels drop too low, turning on an aeration system can quickly increase dissolved oxygen levels. Designed specifically for aquaculture, the YSI 5500D multiDO optical monitor and control instrument (ysi.com/5500D) continuously monitors your operation and automatically controls the aeration system based on preset levels. This instrument allows farms to operate aeration systems more efficiently which significantly reduces energy costs and allows personnel to be used in other areas.

Field testing shows, on average, an automatic system reduces aeration by 4 hours per night. If we assume two 10-hp paddle wheel aerators per pond on a farm with 8 large ponds we can determine a cost savings. Most energy costs are reported in cents per kilowatt hour (\$/kWh). If we assume \$0.1003/kWh for the energy cost and we use the following formula to calculate the cost, we could realize a significant savings through automation.

Energy Cost Savings Example*

$\text{Savings} = (\text{hp}) \times (0.746) \times (\$/\text{kWh}) \times (4 \text{ hours saved per night})$
hp is total horsepower and 0.746 is the conversion from hp to kW

$(2 \times 10 \text{ hp}) \times (0.746) \times (\$0.1003/\text{kWh}) \times (4 \text{ hrs saved}) = \mathbf{\$5.98}$
savings per night per pond

$\$5.98 \text{ per night per pond} \times 8 \text{ ponds} = \mathbf{\$47.87}$ savings per night total

$\$47.84 \text{ per night total} \times 30 \text{ days} = \mathbf{\$1,435.20}$ savings per month

* kWh cost average for March 2010 was 10.03 cents. Source: www.eia.doe.gov

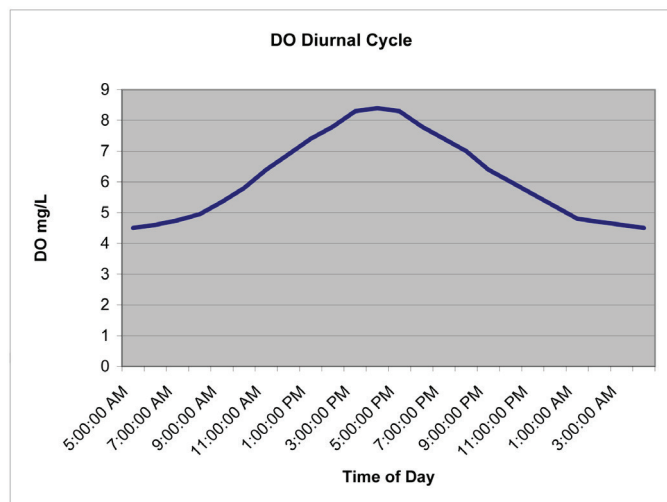
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Graph 1. Typical dissolved oxygen values of diurnal changes in a natural pond system. Heavily planted or stocked ponds can affect the values even more.

The 5500D multiDO monitoring and control instrument allows for multiple inputs so several ponds can be monitored continuously with remote alarming and control capabilities. There are various levels of DO control available, allowing you to input more than one control point. With low control one, you can set it to turn an aerator on. With low control two, you can set it to turn on additional aerators. Both DO controls give you the ability to get the pond back into normal ranges. You can also set a low alarm, which can notify you via email or text message if the first alarm point is reached.

You also have the ability to increase the flexibility and capability of your operation with the YSI Expansion Modules, the IOEM and REM. Configure up to 4 (IOEM-4) or 8 (IOEM-8) channels as inputs or outputs for the ability to integrate 3rd party sensors or output from other devices. Outputs can be configured to control pumps, UV systems, analog valves, or send data to SCADA/ PLC systems. You can also add up to 4 user-configurable relays with the REM (REM-4) to control feeders, lighting, heaters, alarming and more (ysi.com/REM and ysi.com/IOEM).

Some farms operate more manually with workers checking ponds regularly with a handheld instrument such as the YSI ProODO (optical dissolved oxygen) (ysi.com/ProODO) or

the YSI Professional Plus (ysi.com/ProPlus), then manually turning on an aerator or operating a tractor powered paddle wheel. This can be very time consuming and risky since a low DO event could be missed. It could also result in an additional expense, since aerators would need to run continuously to get DO levels back to a normal range.

Not only can a monitoring and control system save on energy costs but it can also have other added benefits.

- Costly fish losses can be eliminated
- Food costs can be reduced by feeding only when the conditions are optimal to feed. The Feed Smart™ software built into the 5500D (or the 5200A or 5400) allows you to control up to four automatic feeders and account directly for feed conversion ratios (FCRs).
- Increased livestock productivity
- Personnel can be used in other areas of the operation more efficiently
- Make confident pond management decisions
- Water quality conditions can be monitored and acted on remotely, providing invaluable peace of mind

For additional aquaculture information including specifications on YSI instruments, please visit:

ysi.com/aquaculture



YSI 5500D multi-dissolved oxygen (optical) instrument with control and alarming capabilities.

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